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ORIGINAL ARTICLE

^{99m}Tc-MIBI Scintigraphy to differentiate malignancies from benign lesions detected on Planar bone scans

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Abstract The aim of study was to evaluate the effectiveness of ^{99m}Tc-MIBI (hexakis 2-methoxyisobutyl isonitrile) scintigraphy to differentiate malignant from benign lesions, detected on ^{99m}Tc-MDP planar bone scans. 59 patients with bony lesions were studied prospectively and compared with histopathology. Each patient underwent a ^{99m}Tc-MDP scan, and if evidence of lesion found, patient underwent ^{99m}Tc-MIBI scintigraphy after three to four days. ^{99m}Tc-MIBI scans were evaluated visually and quantitatively. For quantitative analysis count ratio of lesion to contralateral normal side (L/C) was taken and Student *T* test was applied.

^{99m}Tc-MDP scans showed increase tracer uptake but no significant difference between benign and malignant uptake was seen. Significant difference (*p* value 0.015), was seen in malignant (L/C 3.51 ± 1.02) and benign lesions (L/C 2.50 ± 0.42) on ^{99m}Tc-MIBI scan. Three of thirty benign lesions did not show significant ^{99m}Tc-MIBI uptake. Six malignant lesions appeared as false negatives. Specificity of ^{99m}Tc-MIBI was 86.66%, Negative Predictive Value (NPV) 81.25% whereas the sensitivity was 79.31%.

^{99m}Tc-MIBI scintigraphy provides its usefulness by distinguishing malignant from benign lesions along with correct identification of metastatic lesions. NPV points toward its ability to correctly diagnose the normal (benign) cases. However biopsy still remains the gold standard and a definitive diagnostic modality.

1. Introduction

The development and research of new imaging modalities in musculoskeletal tumors has led to a cascade of analytical techniques improving the potential for noninvasive study of the musculoskeletal system. There are five major roles of imaging

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in the management of primary musculoskeletal tumors, that is, to differentiate between benignity and malignancy, to evaluate for local tumor extension, to screen for metastases, to judge the effect of chemotherapy, and to monitor for recurrence. To accomplish this, multiple modalities are required because no single examination is able to complete all these tasks. These modalities include plain radiography, Computed Tomography (CT), Magnet resonance Imaging (MRI), conventional nuclear medicine as well as Positron Emission Tomography (PET) imaging. For more than 30 years bone scintigraphy has been known as one of the most sensitive noninvasive methods to detect bone pathology. Because of its widespread availability, moderate cost and extensive clinical experience bone scan is still firmly established in the diagnostic algorithm to detect or characterize lesions of all kinds, however it lacks specificity (1). So it is difficult to report a lesion as benign or malignant. The use of specific radiopharmaceuticals permits cost effective imaging and contributes to the preoperative differentiation.

^{99m}Tc-MIBI was originally introduced for myocardial perfusion studies (2). In the previous decade, its noncardiac applications such as visualization of benign and malignant lesions in the lung (3,4), mediastinal and pulmonary metastasis from thyroid cancer (5), astrocytoma (6), and undifferentiated mesenchymal tumor (7) were of great value. ^{99m}Tc-MIBI is a lipophilic cation which is predominantly stored in subcellular structures in response to electrical potentials. Malignant cells maintain a more negative potential secondary to increased metabolic requirements that could promote increased accumulation in malignant cells (8).

This study shows the role of ^{99m}Tc-MIBI to its full extent in preoperative differentiation of benign versus malignant lesions of bone. The requirement of this study arises due to the variations in uptake ratios of ^{99m}Tc-MIBI in this geographical location which may be due to the difference in nature of tumors, their level of differentiation and heterogeneity. Therefore evaluation of a range for ^{99m}Tc-MIBI uptake ratios (in our region) will help the upcoming cases in differentiation between benign and malignant. After the establishment of ^{99m}Tc-MIBI as a tumor imaging and differentiating agent its application can be helpful with the diagnostic algorithm in our centers.

2. Materials and methods

Patients presenting from September 2011 to March 2012 were studied prospectively, 59 patients (24 males, 35 females, age range 3–70 years; mean age, 28 ± 16 years). 48 patients with clinical or radiologic features of primary musculoskeletal tumors and 11 patients with suspected bone metastases were included, a patient having any trauma or fracture noted on X-ray was excluded. Informed consent was obtained from every patient and study was approved by the ethical committee of the institution. All patients were examined before biopsy, and none had received radiotherapy or chemotherapy before imaging.

2.1. Imaging protocol

2.1.1. ^{99m}Tc-MDP scan

After intravenous administration of 20 mCi of ^{99m}Tc-MDP three phase bone scanning of the lesion area was performed. In cases of children under 12 years Webster rule was followed for dose calculation,

$$\text{Dose (mCi)} = \text{Adult dose (mCi)} \times (\text{age in years} + 1)/(\text{age in years} + 7)(9).$$

After the flow phase (2-s images for 90s), static images were taken 3 h later. Whole-body bone scans were also obtained for each patient to assess tumor spread.

2.1.2. ^{99m}Tc-MIBI scan

Three to five days later of ^{99m}Tc-MDP scan 20 mCi of ^{99m}Tc-MIBI was injected intravenously and after 30 min of tracer administration, spot views acquired over the pathologic area (as localized by MDP scan) on a 256 × 256 matrix for 10 min.

All scans were done using a dual head Infinia Gamma Camera with a parallel hole low energy general purpose collimator (LEGP).

2.2. Image interpretation

Each patient first underwent a ^{99m}Tc-MDP scan which was used as a guide to lesion localization followed by ^{99m}Tc-MIBI scan. 3 experienced nuclear physicians blind to the radiologic findings and clinical data analyzed the bone scans visually, each working independently. Only those lesions were considered for ^{99m}Tc-MIBI scan which showed their definitive presence on ^{99m}Tc-MDP scan analysis.

2.3. Data analysis

2.3.1. Qualitative (visual) assessment of ^{99m}Tc-MIBI scans

The lesions were categorized on basis of the radiotracer uptake in accordance with the surroundings. All the lesions on ^{99m}Tc-MIBI scan were categorized in 4 groups as shown in Table 1.

Lesions with negative and mild radiotracer uptake were categorized as benign and lesions with moderate and severe radiotracer uptake were placed in the malignant category.

2.3.2. Quantitative analysis on basis of uptake ratios of ^{99m}Tc-MIBI

This method was employed for the quantitation of uptake of radiotracer in the lesion and contralateral/adjacent normal areas to augment the visual assessment. After 30 min of tracer administration in ^{99m}Tc-MIBI scans a Region of Interest (ROI) was drawn around the lesion and by the help of a computer generated program a exactly similar ROI was drawn on the contralateral side automatically. Whenever contralateral side could not be taken (as in case of spine), ROI was drawn

Table 1 Visual grouping of lesions according to the intensity of ^{99m}Tc-MIBI uptake.

Negative	Lesions having no tracer uptake
Mild	Faint or barely perceptible tracer uptake than the surrounding
Moderate	Well defined, focal increased tracer uptake than the surroundings
Severe	Diffuse intense increased tracer uptake

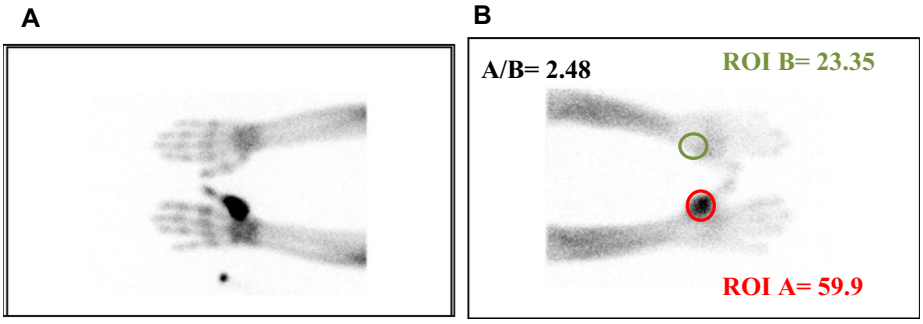

Fig. 1 24 years old female patient with Giant cell Tumor (A) ^{99m}Tc-MDP scan showing increased tracer uptake involving the first metacarpal, (B) ^{99m}Tc-MIBI scan showing an ovoid area of increased tracer uptake over the first metacarpal of right hand, L/C calculated to be 2.48 therefore categorizing lesion as benign. (the ROI around the lesion is colored red and the ROI of contralateral normal side is colored green).

on adjacent normal area and the lesion to contralateral ratio (L/C) was calculated as shown in Fig. 1.

2.4. Statistical analysis

Histopathology of lesion was considered as the gold standard. Findings of ^{99m}Tc-MIBI scan were compared to the results of biopsy, and lesions were categorized as true positive and false positives.

Statistical analysis was performed by the help of SPSS-13 software, and sensitivity, specificity, positive and negative predictive values as well as the accuracy of the diagnostic test were calculated. Chi-square test was applied to determine the significance of ^{99m}Tc-MIBI to distinguish between benign and malignant lesions visually while Independent *t* test was applied for quantitative analysis.

3. Results

59 patients (24 M, 35 F) were studied prospectively. The patient's age ranged from, 3 to 70 years; mean age, 28 ± 16 years. 30 benign and 29 malignant case (48 primary and 11 metastatic) lesions were evaluated. The individual lesions as classified by histopathology are given in Table 2.

Table 2 Number and diagnosis of benign and malignant lesions in the study.

Benign		Malignant	
Diagnosis	Number	Diagnosis	Number
Giant cell tumor	12	Ewing sarcoma	9
Osteomyelitis	4	Ca Breast mets (appendicular)	5
Bone cyst	4	Rhabdomyosarcoma	2
Anurysmal bone cyst	3	Osteogenic sarcoma	2
Fibrous dysplasia	2	Prostrate mets (axial)	2
Exostosis	2	Malignant nerve sheath tumor	1
Osteoid osteoma	1	Chondroblastic osteosarcoma	1
Enchondroma	1	Ewing mets (axial)	1
Chondroblastoma	1	NHL mets axial	1
		Renal cell ca mets (axial)	1
		Leukemia	1
		Synovial sarcoma	1
		Malignant fibrous histiocytoma	1
		Renal cell Ca mets (appendicular)	1
Total	30		29

3.1. Visual analysis

Twenty out of 30 proven benign and 19/29 proven malignant lesions were correctly identified by ^{99m}Tc-MIBI on visual assessment. All lesions were confirmed by histopathology. Negative and mild groups were considered as benign and moderate and severe cases were grouped into malignant category as shown in Table 3. Chi Square test was applied, and the *p* value calculated was 0.03 (< 0.05 is significant), with Df (degree of freedom) = 1.

Therefore visual assessment for differentiation between malignant and benign lesions on ^{99m}Tc-MIBI scan was found to be statistically significant.

Table 3 Visual categorization of lesions on ^{99m}Tc-MIBI scans (n = 59).

Categorization on basis of ^{99m}Tc-MIBI uptake	Number of lesions (%)	Inference
Negative	3 (5%)	Benign
Mild	28 (47%)	
Moderate	10 (17%)	Malignant
Severe	18 (30%)	

3.2. Quantitative analysis

L/C uptake ratios were calculated for all the lesions on ^{99m}Tc-MIBI scan. The mean of all the uptake ratios of ^{99m}Tc-MIBI was calculated and was maintained as the cutoff point. The mean uptake ratio calculated was 2.77 ± 0.86. The lesions having no or less uptake than the mean uptake ratios were designated as benign lesions while the lesions having higher uptake than the mean uptake ratio were designated as malignant.

The distribution of lesions into benign and malignant categories showed that benign lesions were 51% (30 out of 59) and malignant lesions constituted of 48% (29 out of 59) lesions.

3.2.1. ^{99m}Tc-MIBI scanning for benign lesions

^{99m}Tc-MIBI uptake ratios in benign tumors ranged from [0 to 5.34] (Fig. 1). The average uptake ratio calculated for benign tumors was 2.50 ± 0.42 (p value 0.015). 4/30 benign lesions detected by ^{99m}Tc-MIBI on quantitation showed false positive results among them were 2 Osteoid Osteomas (mean L/C ratio 3.53) and two cases of Chondroblastoma (mean L/C ratio 3.35) while two cases of Exostosis showed no ^{99m}Tc-MIBI tracer uptake.

3.2.2. ^{99m}Tc-MIBI scanning of malignant lesions

Twenty-three out of 29 histologically proven malignant tumors showed increased MIBI uptake. ^{99m}Tc-MIBI uptake ratios in malignant tumors ranged from [0.84 to 10.27] (Fig. 2). The average uptake ratio calculated for malignant tumors was 3.51 ± 1.02 (p value 0.015). 06 lesions showed decrease MIBI uptake which included Ewing's Sarcoma, Malignant nerve sheath tumor, metastasis from prostate Ca (2) and Ewing's sarcoma categorized as false negatives.

Mean uptake ratios calculated for more than one cases of the similar pathology showed, the highest uptake ratio in synovial sarcoma (10.06) followed by osteogenic sarcoma (6.27), rhabdomyosarcoma (4.125), Ewing's sarcoma (2.98), breast cancer metastasis in appendicular skeleton.

3.3. Statistical analysis

Independent T test was applied and a highly significant difference was found between the L/C of benign and L/C of malignant tumors ($p < 0.005$).

t value −3.150 with degree of freedom = 57. The mean uptake of the two groups was 2.77 ± 0.86.

The performance parameters were calculated for 59 patients as tabulated in Table 4. ^{99m}Tc-MIBI scan was 83.05% accurate in differentiation of malignant tumors from benign lesions and all results are shown in Table 5.

Table 4 The results and number of patients underwent ^{99m}Tc-MIBI scintigraphy.

Results	No. of patients
True positive for malignant tumor	23
True negative for malignant tumor	26
False positive	4
False negative	6
Total	59

Table 5 Quantitative result keeping histopathology of bone biopsy as gold standard.

Sensitivity	79.31%
Specificity	86.66%
NPV	81.25%
PPV	85.18%
Accuracy	83.05%

Mean uptake ratio of the two groups is 2.77 ± 0.86. Most uptake ratios of malignant tumors are greater than mean, whereas most uptake ratios of benign lesions are less than mean. The comparison of malignant and benign uptake ratios is shown in Fig. 3. The uptake ratios of malignant tumors are ranging from 0.8 to 10.27, with the major ratios lying between 2 and 4, whereas the range of uptake ratios of benign lesion is from 0 to 5.34 and major ratios falling between 2 and 2.62.

4. Discussion

Various radiopharmaceuticals have been proposed as bone tumor imaging agents. X-rays, CT, MRI, nuclear medicine as well as PET imaging are used in diagnostic algorithm all

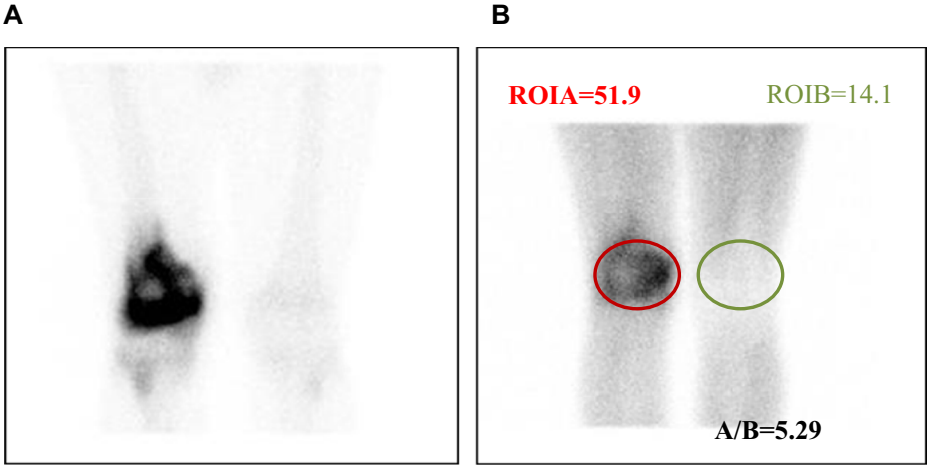

Fig. 2 45 years old male patient of Osteosarcoma of right distal femur (A) ^{99m}Tc-MDP scan showing increased tracer uptake involving the distal part of right femur (B) ^{99m}Tc-MIBI scan showing an area of increased tracer uptake over distal part of right femur with a L/C of 5.29 therefore categorizing lesion as malignant (the ROI around the lesion in colored as red and the ROI of contralateral side is colored green).

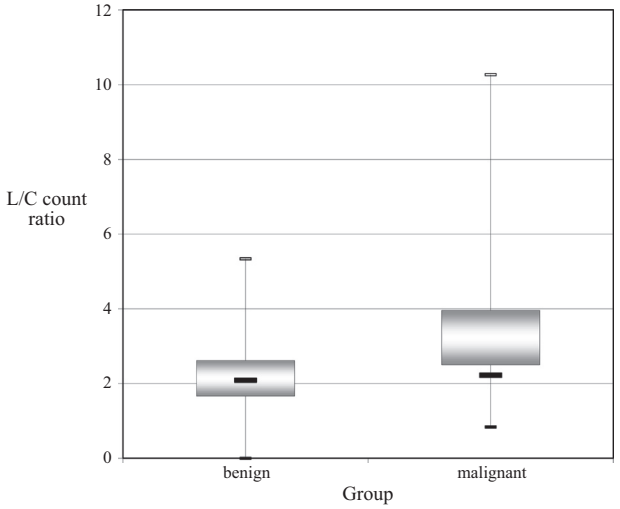

Fig. 3 Comparison between ^{99m}Tc-MIBI ratios of malignant and benign lesions. Box and whisker graph demonstrates the comparison between the ratios of malignant and benign lesions and the boundary closest to zero indicates the 25th percentile and boundary farthest from zero indicates the 75th percentile. Whiskers indicate the outliers lying at the 10th and 90th percentiles.

over the world. Principal role of radionuclide bone imaging is to determine whether the process is multifocal. It is of low specificity because it does not discriminate between benign and malignant lesions although highly sensitive. It is also not possible to distinguish a healing process from other active metabolic processes, such as tumor recurrence or metastases. As the diagnosis of bone lesions is very crucial and requires prompt diagnosis, so accurate differentiation between benign and malignant lesions is of paramount importance (10). ^{99m}Tc-MDP skeletal scintigraphy is among the imaging techniques employed for evaluation of bony lesions. The high sensitivity correlates with a lower specificity because many benign conditions, such as degenerative joint disease, infections, and benign bone tumors, exhibit increased uptake of radiotracer, and if lesion is solitary reliable differentiation cannot be achieved. Biopsy still remains the gold standard in the definitive diagnosis, but it is subject to error and consequent complications, and also in cases of benign lesions the patient undergoes under an unnecessary procedure. These problems led to the research of a new technique which could effectively distinguish between benign and malignant lesions.

Bone tumor imaging agents such as ^{67}Gallium are popular, but poor physical characteristics, long waiting periods, and its lack of specificity are disadvantages (11). ^{201}Thallium has been proposed to be a sensitive radiopharmaceutical for detection of bone sarcoma and evaluation of response to therapy. Yet its long biologic half-life limits the administered dose, frequently resulting in long imaging times. Therefore use of these radiopharmaceuticals with the passage of time is diminishing with the advent of new radiopharmaceuticals appropriate in all aspects. ^{99m}Tc-MIBI is a well known myocardial perfusion agent (12). Following the inadvertent discovery of the uptake of ^{99m}Tc-MIBI in a lung cancer by Delmon Moingeon et al. in 1990, led to its evolvement as a tumor imaging agent due to its uptake in various human cell lines (13). The distribution of ^{99m}Tc-MIBI in vivo is not only a simple function of blood flow, but also represents metabolic function. The uptake of ^{99m}Tc-MIBI apart from blood flow depends upon the cell viability, metabolic conditions, and its retention mechanism (5,7,14). It also has the ability to differentiate post therapeutic necrosis from residual viable tumor tissue or local recurrence, therefore clearly over riding the CT and MRI in detection of viability of tumor. This is achieved by both qualitative and retention mechanisms of ^{99m}Tc-MIBI, which depends on mitochondria and negative membrane potential (15). 99mTc has a shorter physical half-life of 6 h which permits the use of a higher administered dose as compared to 201Tl, which translates to a higher count rate which will shorten imaging times and provide clear and better resolution images. The gamma energy of 99mTc (140 keV) is optimal for use with the detector crystal used in the gamma camera and will undergo less attenuation and scatter. Aktolun et al. (16) compared the differences in ^{99m}Tc-MIBI and ^{201}Tl uptake in 17 patients with known malignancy mainly breast and lung cancers and the uptake ratios were found to be similar, except for 1 patient of breast cancer which was only localized by ^{99m}Tc-MIBI.

Another study conducted on brain tumors showed that both the radiotracers showed uptake in tumor cells but 6 of the cases showed increased lesion to normal side ratio for ^{99m}Tc-MIBI (6). Taking into consideration these studies it can be depicted that the tumor cell lines are clearly localized by both ^{99m}Tc-MIBI and ^{201}Thallium but due to the favorable characteristics, sufficient dose can be given in ^{99m}Tc-MIBI for radionuclide angiography, and hence blood pool studies can also play a role in assessment and localization of tumor with ^{99m}Tc-MIBI which cannot be done with Thallium.

^{99m}Tc-MIBI provides better localization and categorization of bone and soft tissue lesions into benign and malignant categories as compared to other imaging modalities. A study conducted by Moustafa et al. (17) showed 6 false positives among 24 adequately controlled bone and soft tissue tumors which were falsely diagnosed by CT/MRI as positive recurrent tumor which were not evident on MIBI scan and biopsy. The sensitivity, specificity, and accuracy of ^{99m}Tc-MIBI in detection of bone, soft tissue tumors were 93%, 95%, and 92% as compared to CT, MRI which were 86%, 75% and 84%, respectively.

There are studies in which ^{99m}Tc-MIBI uptake ratios were compared with ^{99m}Tc-MDP. Caner et al. also reported that, the extent of the pathology seen on ^{99m}Tc-MDP images was generally larger and showed greater uptake ratios than that on the corresponding ^{99m}Tc-MIBI images. This was thought to be due to the assumption that ^{99m}Tc-MDP uptake is a reflection of both bone blood flow and osteoblastic activity, while ^{99m}Tc-MIBI is taken up by the tumor cells, whether it is bone or soft tissue. In patients with extensive uptake pattern with ^{99m}Tc-MIBI, the soft-tissue component of the tumor in addition to bone involvement was detected histologically (7).

In our study that was conducted to differentiate malignant from benign lesions, there were a total of 59 lesions, in which there were 29 malignant lesions of which 11 were metastatic bone lesions. The objective of our study was to categorize the lesions noted on ^{99m}Tc-MDP as benign or malignant on the basis of ^{99m}Tc-MIBI scan.

On qualitative (visual) analysis the lesions were significantly differentiated 20/30 and 19/29 lesions were correctly identified. Benign lesions showed increased ^{99m}Tc-MIBI uptake and then

the criteria for benign lesions visually included cases of giant cell tumor and chondroblastoma. This may be due to the increase in vascularity and high level of metabolic activity of the cells, whereas the metastatic lesions located in the axial skeleton and some cases of Ewing's sarcoma showed decreased ^{99m}Tc-MIBI uptake. The groups were statistically analyzed and the result was significant. Therefore, enabling the worth of ^{99m}Tc-MIBI in visual assessment (p value 0.03).

On quantitative analysis 22/29 (76%) lesions showed increased tracer uptake and 7 lesions (24%) showed less tracer uptake than the mean uptake ratio calculated for malignant tumors. 23/30 (77%) benign lesions showed less tracer uptake. 3 (10%) benign lesions showed no tracer uptake while 4 lesions (13%) showed increased tracer uptake than the mean uptake ratio calculated for benign tumors. The mean uptake ratio calculated for the two groups was 2.77 ± 0.86. The quantitative analysis was more significant than the visual analysis (p 0.015 and 0.03 respectively). Therefore 23 cases were true positives for malignant tumors and 26 were true negatives. The test was 79.31% sensitive, 86.66% specific with a negative predictive value (NPV) of 81.25% and 83.05% accurate (Table 5) as compared with Pinkas et al. which was 87% specific and 81% sensitive.

Most malignant tumors (22/29) showed increased tracer uptake with a mean L/C ratio of 3.51 ± 1.02. The uptake ratios of malignant tumors were noted to be higher than the mean uptake ratio of both groups. These results compared to results by Pinkas et al. (18) show better differentiation between malignant and benign lesions. Metabolism, necrosis and some other factors might cause these uptake differences. The highest L/C was found to be of synovial sarcoma which was significantly higher than the uptake ratios in other tumors. In a similar study conducted by Rodriguez et al. (19) with different radiopharmaceuticals in different soft tissue sarcomas, synovial sarcoma was seen to have highest uptake ratio. Differences in metabolic capacity between cell types may thus account for the heterogeneity of uptake seen in synovial sarcoma and other malignant tumors.

The intensity of uptake in Ewing's sarcoma was quite variable and ranged from 1.19 to 4.16. The mean uptake ratio of Ewing Sarcoma was 3.02 ± 0.84. In this study it was noted that out of 9 cases of Ewing's Sarcoma 1 case showed decreased tracer uptake than the mean uptake ratio, while 3 cases showed borderline uptake while 5 cases showed high uptake ratios. Similar results were also appreciated in the study conducted by Caner et al. (20). Recent studies show that an osseous equivalent of a malignant, small cell neoplasm of neural crest origin apparently exists within the bones (Askin's tumor) and its differentiation from Ewing's sarcoma is difficult (21,22). The tumors diagnosed as Ewing's sarcoma that showed mild tracer uptake on the ^{99m}Tc-MIBI images might be such newly described tumors originating from the neural crest. A detailed histopathological evaluation and immunohistochemistry are needed to differentiate between Ewing's Sarcoma and Askin's tumor. Thus it shows that uptake of MIBI not only depends on the tumor type but also on its level of differentiation, metabolism, blood supply, viability and level of necrosis.

Similar studies carried out over the period of time for differentiating malignancies from benign lesions, have yielded similar results as seen in Zhi-yun et al. (23), however the ratios of benign and malignant tumors are different owing to the difference in geographical location, tumor grade, level of differentiation of tumors and grade of heterogeneity. The summary of studies in comparison with our study in summarized in Table 6.

Table 6 Comparison of ^{99m}Tc-MIBI uptake ratios with previous studies.

Serial number	Study name	Benign	Malignant
1	Pinkas et al.	1.22 ± 0.43	2.25 ± 1.03
2	Caner et al.	1.26 ± 0.40	2.21 ± 1.17
3	Taki et al.	1.82 ± 1.11	2.01 ± 0.99
4	Present study	2.5 ± 0.42	3.51 ± 1.02

23 of 30 (79%) benign tumors showed ^{99m}Tc-MIBI uptake. While 3 benign tumors showed no uptake on ^{99m}Tc-MIBI scan, 2 of these lesions were confirmed as bone cyst and 1 lesion was found out to be exostosis. Osteomyelitis (L/C 5.34) shows the highest uptake followed by giant cell tumor (L/C 4.73) and osteoid osteoma (L/C 3.53) making as false positive.

Giant cell tumor (GCT) showed increased tracer uptake than the mean uptake ratio, similar results are seen in the studies conducted by Pinkas et al. (18) and Taki et al. (24), GCT is a heterogeneous tumor composed of three different cell populations. The giant-cell tumor stromal cells (GCTSC) constitute the neoplastic cells, the mononuclear histiocytic cells (MNHC) and multinucleated giant cell (MNGC) fractions are secondarily recruited and comprise the non-neoplastic cell population. The GCTSC lineage is responsible for the increase in tracer uptake and false positive result on ^{99m}Tc-MIBI scans (25).

^{99m}Tc-MIBI detects lesions located in the axial skeleton as seen in study by Wakasugi et al. (26), but it poses difficulty in differentiating of lesions usually located in the axial skeleton. Lesions located axially are not clearly differentiated due to the masking of activity of the gut and heart. Due to this reason ^{99m}Tc-MIBI poses difficulty when lesions are placed in sternum or spine, the activity of the heart and gut as higher in counts masks the activity seen in the lesion and hence the lesion is not localized.

Newer modalities are being used for detection of musculoskeletal tumors one of them is FDG-PET. Tumor imaging with FDG is based on the hypothesis that the rate of anaerobic glycolysis increases with differentiation of tumor cells and with an increasing grade of malignancy. Several different neoplasms have been imaged with FDG since the first demonstration of its ability to localize cerebral gliomas (27). PET imaging of musculoskeletal masses does have certain pitfalls given its limited resolution. There must also be some concern about the natural variability of FDG accumulation in benign or malignant processes, since numerous factors (i.e., blood flow, plasma glucose concentration and tissue hexokinase activities) in addition to glucose metabolic rate determine FDG accumulation and the nonavailability and high cost of the test limits its usefulness. FDG-PET and ^{99m}Tc-MIBI-SPECT are useful adjunct tools in the evaluation of musculoskeletal tumors, particularly in distinguishing between benign and malignant tissue components (28). If there is clinical or histological evidence of recurrence but the ^{99m}Tc-MIBI-SPECT is negative, a more expensive FDG-PET scan is recommended to investigate possible drug-resistance. Therefore ^{99m}Tc-MIBI is cost effective,

sensitive and provides good evaluation and differentiation of lesions.

^{99m}Tc-MIBI plays an important role in imaging of non-specific lesion detected on bone scans; it provides precise localization, defines the morphological significance and improves the specificity of planar bone scan. The results of our study showed that MIBI improves the accuracy of diagnosis of a lesion as benign or malignant.

5. Conclusion

This study suggests that ^{99m}Tc-MIBI scintigraphy plays an important role to distinguish malignancies from benign lesions which are detected on planar bone scan with good sensitivity and high specificity. Its high PPV renders it a good diagnostic option for differentiation of lesions. Biopsy still remains the definitive diagnostic modality but ^{99m}Tc-MIBI provides clue to the diagnosis and can help in preventing unnecessary intervention in benign lesions. ^{99m}Tc-MIBI provides better results when analyzed quantitatively as compared to visual assessment.

Conflict of interest

There are no conflict of interest between the authors.

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